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First Observation of Laser Satellite Transitions in High-Intensity Laser Plasma Interactions

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The oscillating electromagnetic field of an intense laser pulse can significantly affect the emission properties of ions in a plasma. For sufficiently intense laser fields, new discrete emission lines are predicted to appear. Anti-Stokes scattering of the laser radiation and induced two-photon emission produce two spectral lines separated by $\hbar\omega_{las}$ from the energy of each forbidden transition. We report on the first observation of these satellites, which were measured in experiments performed at the 100 ps Janus laser facility in which titanium targets were irradiated at laser intensities near 10^{17} W/cm^2. A high resolution ($\lambda/\Delta\lambda > 10000$), high luminosity spectrograph with a spherically bent mica crystal was used to observe the emitted K-shell radiation of Ti XII with spatial resolution of 18 μm. Spectra of the He-α and He-β lines with satellites were observed and wavelengths were measured with an accuracy of 0.00012 Å. We observed laser satellites induced from the 1s2s $^1S_0$, 1s3s $^1S_0$, and 1s3d $^1D_2$ metastable levels. An emission model which includes the laser satellites agrees well with the measured spectra.

In addition to producing new spectral lines, these induced radiative processes alter the level population kinetics. We discuss the effects of these processes on the spontaneous radiation spectrum, as well as implications for some x-ray laser schemes pumped by intense, short-pulse lasers.

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